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Perspectives on Lowering Diesel Emissions

Deere Approach to Emissions

- Lower them
  - Redesign engines for lower emissions
- Mitigate them
  - New fuels and after-treatments
  - Reduce demands on engine
- Eliminate them

Lower Diesel Engine Emissions

- Tier III
  - Engine redesign
  - Efficiency improvements
    - Manage additional heat discharge
    - Overcome lower combustion efficiencies

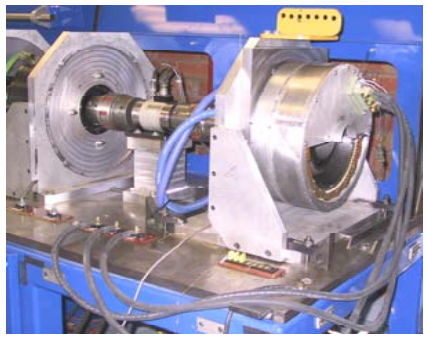
Mitigate Diesel Emissions

- Tier IV
  - Exhaust after-treatment
  - Alternate fuels
  - Systems redesign
    - Electric auxiliaries
    - Electric hybrids

Vehicle Electrification

- Idea:
  - Centralized belt drives
  - Centralized cooling
  - Independent component management
  - Electrical propulsion drives
- Anticipated Result
  - Alternator 1%
  - Engine Coolant Pump 2%
  - Engine Oil Pump 3%
  - Cooling Fans 8%
  - Transmission Pumps 8%
  - Hydraulic Pumps 2 - 8%

Foundation Architecture

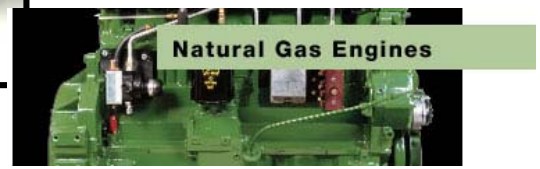


Eliminate Diesel Emissions

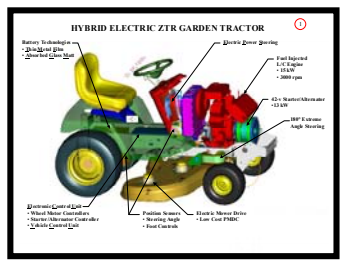
- Hydrogen
  - Hydrogen ICE
  - Hydrogen fuel cells

Deere Alternative Power

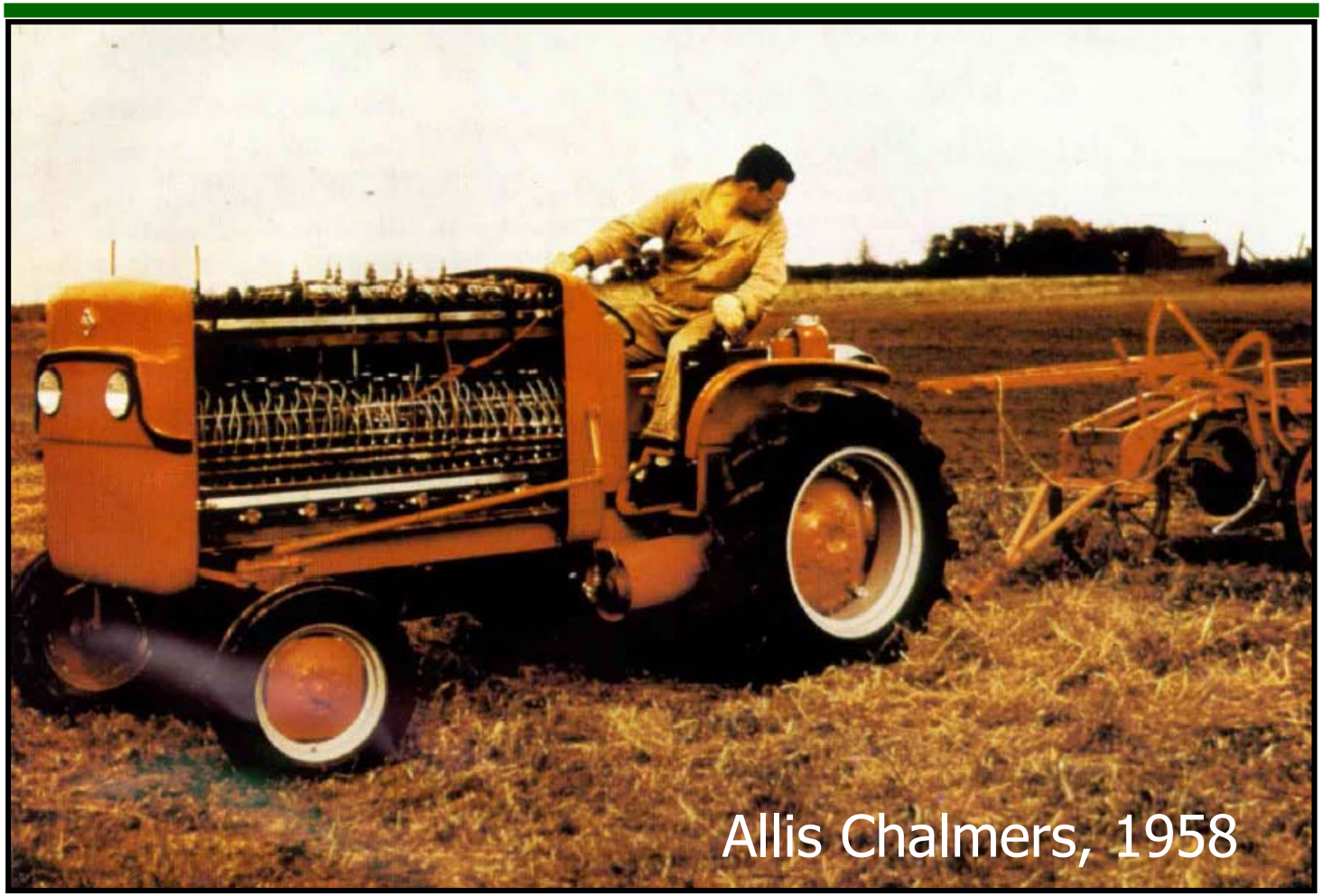
- Current products
  - eGator
  - CNG engine



- Concepts & demonstrators
  - Destiny/ Sprite/ 4000 SR
  - Gators
  - Lawn tractors/ mowers
  - Vehicle and engine auxiliaries



The World's First Fuel Cell Vehicle



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The Hydrogen Economy

Why transform America to hydrogen?

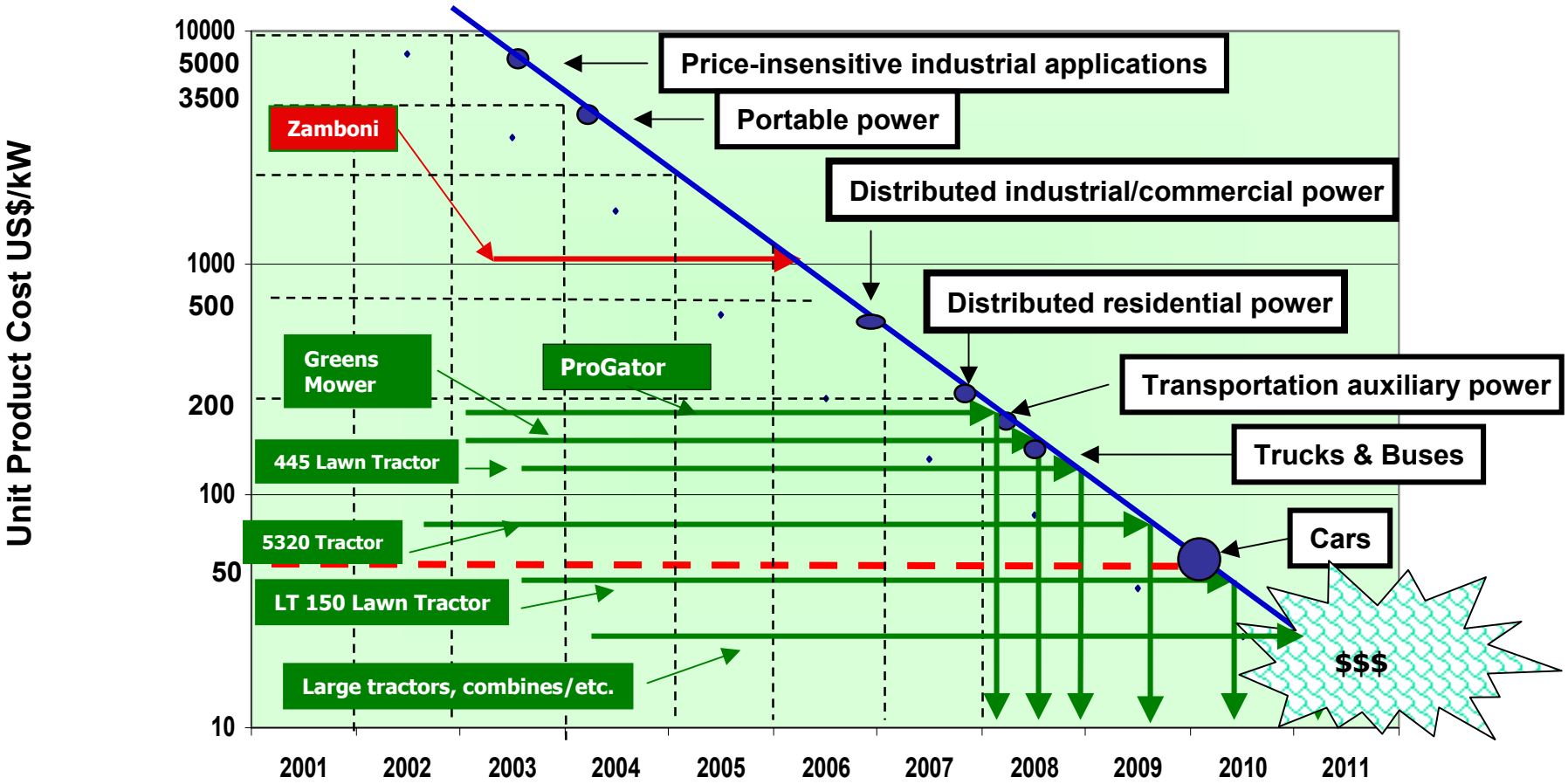
1. Reduce dependence on oil
2. Slow the generation of greenhouse gases
3. Improve industrial and commercial productivity

#1 and #2 are necessary,
but #3 is required

Issues to a Hydrogen Economy

- Technology
  - Electric drives, power electronics & controls
  - Fuel cells, batteries & hybrid power sources
- Energy policy
- Environmental policies
- Market acceptance
- Refueling infrastructure
- Cost

Projected FC Power Pack Cost



Source: *Goepel McDermid, Energy Technology Perspectives,2000*

Modified – JD – 5/2002

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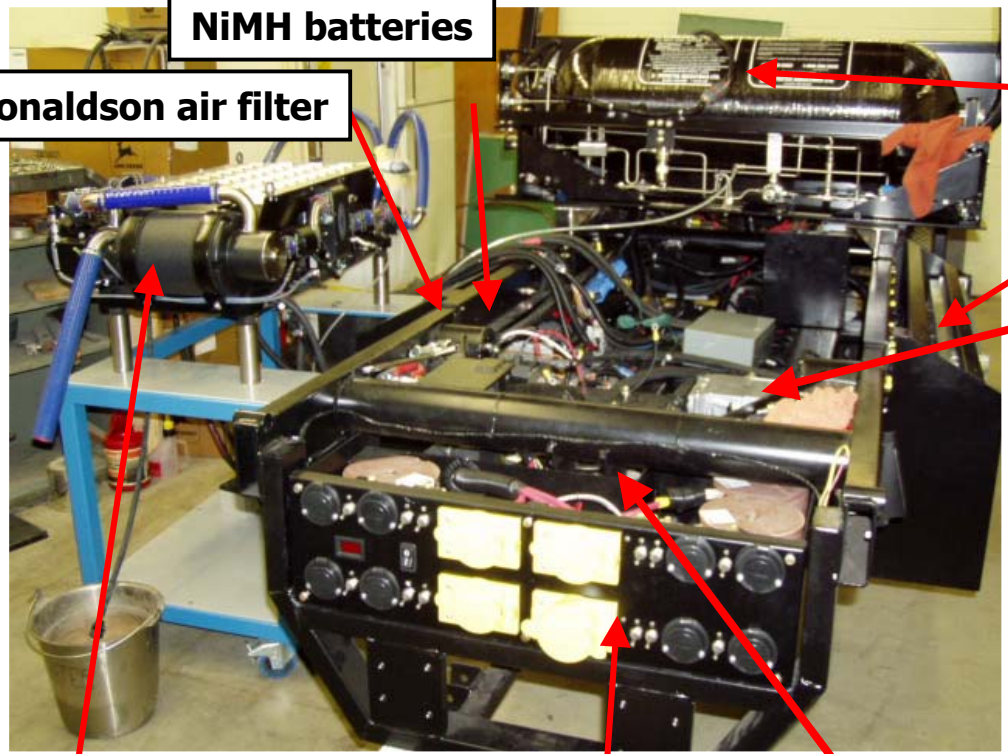
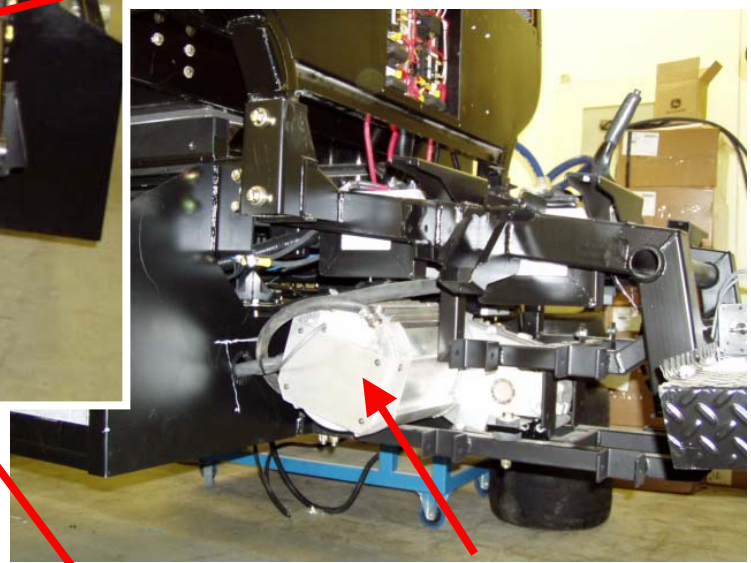
The John Deere H_2 Hypothesis

- **John Deere can advance the introduction of significant numbers of fuel celled vehicles by 5 or more years before significant automobile applications**
  - **Better customer economics**
  - **Off-road fleet based opportunities**
  - **Extensive specialized support**
  - **More ready customer acceptance**

Fuel Cell Hybrid CWV





NiMH batteries

Donaldson air filter

Dynetek 5000 PSI (350 bar) hydrogen storage tank

EMP heat exchanger

Phoenix vehicle controller

Hydrogenics 20kW low pressure fuel cell

20 kW power strip
3-30/50Amp 240V
8-20Amp 120 V

Solectria drive motor and gear box and power inverter

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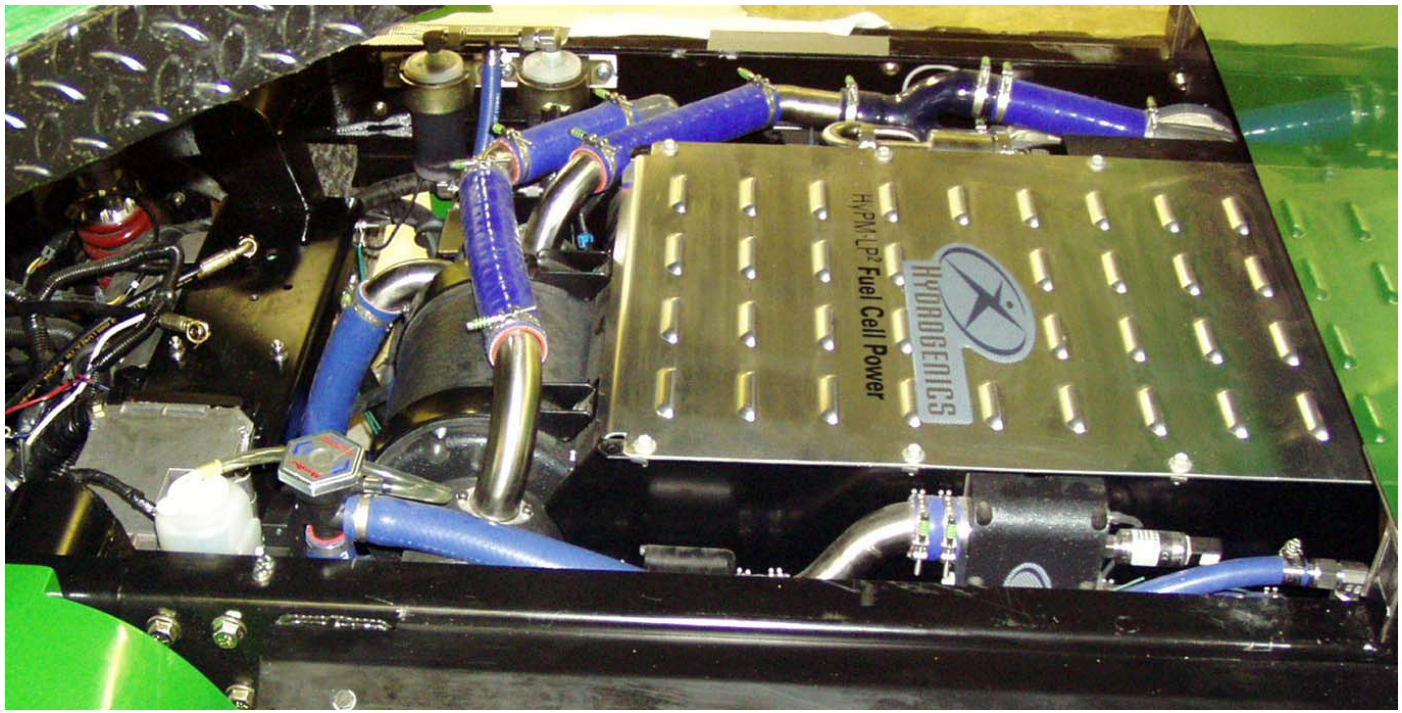
Hydrogenics Fuel Cell



Fuel Cell Hybrid CWV

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Conclusions

- Reducing emissions requires near-term actions and long term innovations
- Electrification is likely to be mandatory too meet Tier IV
- Hydrogen and fuel cells offer the long term solution